Muscular and Functional Performance Characteristics of Individuals Wearing Prophylactic Knee Braces

Paul A. Borsa, MS, ATC
Scott M. Lephart, PhD, ATC
Freddie H. Fu, MD

Abstract: *The efficacy of prophylactic knee bracing has been refuted with regard to reducing the incidence and/or severity of injuries to the knee joint. This is thought to be a result of the prophylactic knee brace's ineffectiveness in protecting the knee joint from valgus loads. Furthermore, discrepancies exist regarding the prophylactic knee brace's detrimental effect on functional performance. The purpose of this study was to measure the effect of the prophylactic knee brace on selected isokinetic muscular characteristics and forward sprint speed. Twenty physically active, healthy, male college students with no prior history of brace use participated in this study. The subjects were randomly tested both with and without the prophylactic knee brace worn on various performance parameters. The dependent measures assessed included peak torque (PT) and torque acceleration energy (TAE) at 60 and 240°/s. A 40-yard forward sprint was selected to assess sprint speed. A paired t-test analysis revealed mean values which were significantly less for PT at 60°/s ($p < .05$), 240°/s ($p < .01$), and TAE at 240°/s ($p < .05$) with the prophylactic knee brace applied during knee extension. Analysis also revealed slower times for sprint speed ($p < .01$), while the subjects were wearing the prophylactic knee brace. Muscular strength (PT) and power (TAE) scores were not correlated ($p > .05$) with sprint speed. This study suggests that wearing the prophylactic knee brace may consequently inhibit muscular and functional performance of the athlete, but that specific population has yet to be studied.*

Paul A. Borsa is a doctoral student in the Exercise Physiology/Athletic Training Program at the University of Pittsburgh in Pittsburgh, PA 15261.
Scott M. Lephart is Director of Sports Medicine/Athletic Training, an assistant professor in the School of Education, and an assistant professor in the School of Medicine, Department of Orthopedics, at the University of Pittsburgh.
Freddie H. Fu is a Blue Cross/Blue Shield of Western Pennsylvania Professor of Orthopedic Surgery, and Team Physician at the University of Pittsburgh.

Epidemiological studies have recognized that knee joint injuries are the most common disabling injuries in athletics.[24,28] Consequently, the use of prophylactic lateral knee braces in football has increased in an attempt to reduce the incidence and/or severity of injuries to the knee joint.[10–12,14,27–31] The efficacy of such knee braces has been refuted by researchers regarding prevention of laterally applied valgus loads that may induce ligamentous injuries to the knee joint.[1,2,6,21,22] The discrepancies in the efficacy of the prophylactic benefits of the prophylactic knee brace have led to inconsistencies among clinicians recommending their use.

Inconsistencies in the available literature have elicited further scrutiny regarding the effects and possible decrements in functional performance while wearing the prophylactic knee brace. The prophylactic knee brace may inhibit leg muscle function and sprint speed, both of which are essential to athletic performance.[7,13,25] Thus, the term "functional" as used in this manuscript implies dynamic muscular activity objectively measured for comparative analysis.

The purpose of this study was to address these discrepancies in the literature by objectively measuring selected isokinetic muscular characteristics and sprint speed under the braced and nonbraced conditions. We hypothesized that the isokinetic muscular test scores would be significantly decreased and forward sprint times would be significantly slower in the braced condition, suggesting functional inhibition.

Furthermore, there has been some debate suggesting that sprint speed is related to muscular strength and power.[15] Since these three performance parameters were measured in this study, we also hypothesized that strength measured as peak torque (PT), power measured as torque acceleration energy (TAE), and sprint speed would be positively correlated all during the nonbraced condition.

Methods

Twenty physically active, healthy, male college students (age = 21.3 ± 3.6 yr, ht = 68 ± 2.4 in, wt = 167 ± 7.2 lb) with no prior history of brace use voluntarily participated in this study. Exclusion criteria included any previous knee pathology requiring surgical intervention, anterior cruciate ligament deficiency, and/or patellofemoral dysfunction. Informed consent approved by the Institutional Review Board at the University of Pittsburgh were reviewed and signed by each subject prior to testing. The subject acted as his own control and was tested on two separate sessions for both conditions (braced versus nonbraced).

The test conditions (brace or nonbrace) were randomized, thus preventing the occurrence of any learning effects. The subjects attire consisted of a t-shirt, gym shorts, and athletic shoes.

Two commercially available prophylactic knee braces were used according to the manufacturer's specifications. They were selected due to their popular use among intercollegiate football players. The McDavid Knee Guard (MKG) (M-155; McDavid Knee Guard Inc, Clarendon Hills, Ill) has a single-hinge design, while the Omni (Omni Scientific Inc, Lafayette, Ill) has a double or polyaxial design (Fig 1). The two prophylactic knee braces were randomly assigned to subjects with 11 wearing the MKG and 9 the Omni. The prophylactic knee brace was worn unilaterally on the dominant leg for the isokinetic tests (Fig 2), and bilaterally for testing sprint speed (Fig 3).

Subjects were tested with identical protocols on two separate days, and the sessions were separated by 48 hours to allow for proper recovery. Test protocol consisted of testing for strength and power on the Cybex unit and sprint speed on an indoor track.

Isokinetic muscular testing was computed using the Cybex II isokinetic testing device (Lumex, Inc, Ronkonkoma, NY). Subjects complet-

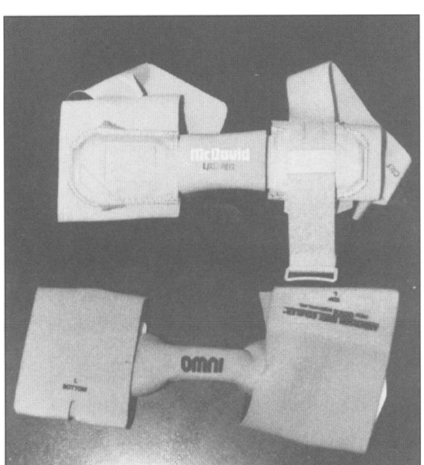

Fig 1.—The McDavid Knee Guard (*top*) is a single-hinge design, while the Omni (*bottom*) is a double- or poly-hinge design.

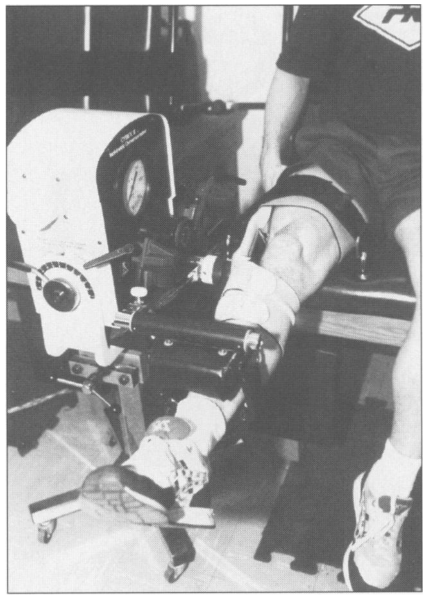

Fig 2.—During isokinetic testing, the prophylactic knee brace was worn unilaterally.

ed a 5-minute warm-up on a Monarch stationary bicycle at a preset cadence (70 rpm) and resistance (.04 kg) relative to the subject's body weight (eg, 60 kg × .04 = 2.4 kp). Cybex testing was conducted in an isolated, thermoneutral environment. The parameters selected for testing included PT and TAE measured at two angular velocities (60 and 240°/s). Peak torque is defined and measured as the greatest torque produced during a given set of contractions, while TAE is defined and measured as the amount of work performed in the first one eighth of a second of torque production.[5] Peak torque is recorded as a strength measure, and TAE is recorded as an anaerobic power output measure in this study.[17,23] Each subject was tested using gravity correction, and standard stabilization was employed at the chest, waist, and distal thigh.[3,4] The Cybex was calibrated prior to testing of the subjects. Each subject received verbal instructions prior to testing, followed by five pretrial submaximal repetitions at 60°/s in order to accommodate to the test speed. After a 30-second recovery, subjects completed four maximal repetitions and the highest value was recorded as PT. A 1-minute recovery was given before continuing at the next test speed. Ten submaximal repetitions were used as a pretrial for testing at 240°/s in order for the subject to accommodate with the faster test speed. After a 30-second recovery, subjects completed four maximal repetitions and the highest values were recorded as TAE and PT.

For testing sprint speed, the subjects went through a warm-up consisting of light jogging for 800 meters and large muscle group flexibility exercises. Each subject familiarized himself with the sprint distance by completing two submaximal trial runs. The 40-yard forward sprint was selected, due to its reproducibility and relevance to college football. The sprint was performed at maximal speed with the mean time (seconds) of three trials recorded as the criterion measure. A 1-minute recovery period was given between trials. Sprint times were recorded by the same investigator using a hand-held stopwatch measured to the nearest tenth of a second.

Analysis of variance (ANOVA) was used to identify significant ($p < .05$) differences between the two prophylactic knee brace designs on the various testing parameters. The selected isokinetic and sprint speed tests were treated as four separate tests and paired *t*-test analyses ($p < .05$) were used to compare the braced and the nonbraced (control) conditions for the

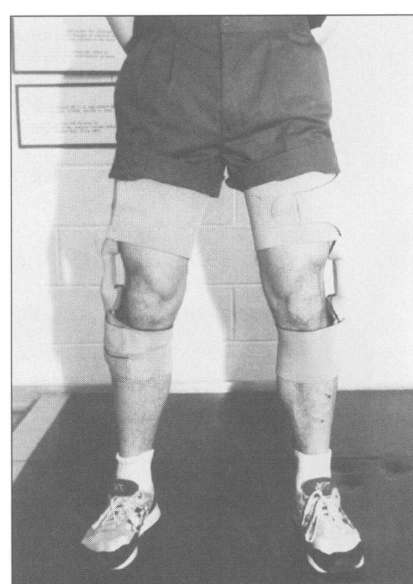

Fig 3.—Frontal view of the prophylactic knee brace.

Table 1.—Means and Standard Deviation for Knee Extension With and Without the Brace

	Brace	No brace
Knee extension (ft-lb)		
Peak torque 60°/s	152.9 (26.3)	158.3 (23.9)
Peak torque 240°/s	51.7 (11.9)	54.4 (12.4)
TAE 240°/s	29.6 (5.6)	31.2 (5.2)
40-Yard forward run (seconds)	5.3 (0.3)	5.2 (0.4)

selected measures. Also, Pearson Product Moment Correlations were computed to determine significant ($p < .05$) correlations between strength (PT at 60 and 240°/s), anaerobic power (TAE) at 240°/s, and sprint speed (40-yard forward sprint).

Results

There were no statistically significant ($p < .05$) differences between the two designs on the various testing parameters ($F(1,18) > 3.73$, $p > .07$). Therefore, the data were pooled, and further analyses were performed without regard to brace design.

Isokinetic strength and power scores were significantly lower while wearing the brace during knee extension for PT at 60°/s ($t(19) = 1.80$, $p = .04$) and 240°/s ($t(19) = 2.66$, $p = .008$), and TAE at 240°/s ($t(19) = 2.19$, $p = .02$; Table 1). Subjects ran faster (40-yard forward sprint) when the braces were not worn ($t(19) = 3.05$, $p = .003$; Table 1). Correlations between strength (PT at 60 and 240°/s), and sprint speed were low and not significant ($p < .05$) (PT at 60°/s and sprint speed ($r = .21$), and PT at 240°/s and sprint speed ($r = .11$)). Also, correlations between power and sprint speed were low and not significant ($p < .05$) (TAE (240°/s) and sprint speed ($r = .37$)).

Discussion

The original premise for wearing prophylactic knee braces was to prevent or reduce the incidence and/or severity of knee joint injuries. Retrospectively, researchers began conducting longitudinal studies comparing injury rates before and after the prophylactic knee brace was being used. Subsequently, the results of these long-term epidemiological studies suggest that prophylactic knee bracing does not reduce the incidence and/or severity of injuries to the knee joint of college football players, specifically injuries to the medial collateral ligament, anterior cruciate ligament, and medial meniscus.[10,12,14,27–31] This has led other investigators[1,2,6,21,22] to conduct biomechanical in vivo and in vitro studies designed to measure brace function under simulated conditions. Paulos et al[6,21,22] and Baker et al[1,2] have pioneered these studies evaluating the static stabilizing qualities of the prophylactic knee brace using both cadaveric and surrogate knee models. They concluded that the prophylactic knee brace does not prevent valgus loading of the knee joint from laterally applied contact blows. Other investigators[26,32] speculated that the prophylactic knee brace is not designed and constructed sufficiently to transfer valgus loads away from the knee joint (Fig 4).

In addition to the prophylactic knee brace's questionable efficacies, many researchers are unclear as to the effect the prophylactic knee brace has on various performance parameters. To date, the degree to which the prophylactic knee brace inhibits functional performance is inconsistent in the literature and has resulted in considerable controversy.[7,13,23] Therefore, if the prophylactic knee brace fails to perform as initially prescribed and also inhibits athletic performance, then it should not be recommended for athletic use.

This study revealed that prophylactic knee braces do indeed inhibit specific performance parameters in subjects unaccustomed to wearing prophylactic knee braces, and this inhibition may result in subsequent decrements in athletic performance. In our study, generation of PT and TAE during knee extension at 60 and 240°/s was found to be significantly inhibited while wearing the prophylactic knee brace, as was forward sprint speed. Others reported similar findings; higher PT values at four angular velocities (30, 90, 180, and 300°/s) without the brace[13] and forward sprint speed deficits when the prophylactic knee brace was worn.[7,25] These findings are inconsistent with reports by Hansen[11] and Clover (unpublished research, Riverside, Calif, 1984) suggesting that prophylactic knee brace's have no effect on isokinetic muscular function.

Houston and Goemans[13] reported significant differences in maximal anaerobic power output on the Margaria-Kalamen (M-K) step test, suggesting that the knee braces may have an inhibitory or "dampening" effect on peak anaerobic power output. This finding supports our study in that peak anaerobic power output decreased significantly when the braces were worn. Anaerobic power output was measured in our study using the TAE value recorded at 240°/s on the Cybex (Table 1). TAE, as defined earlier in the text, is a measure of instantaneous power output

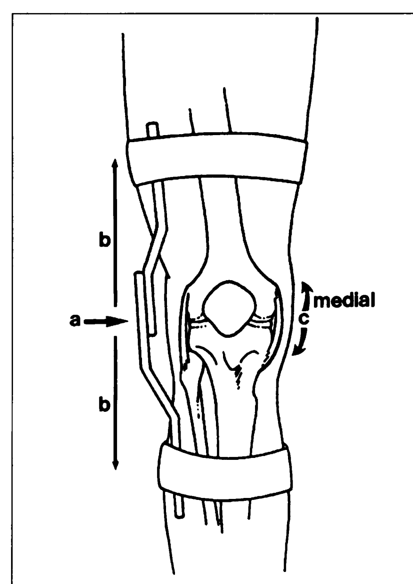

Fig 4.—The prophylactic knee brace is designed to: (*a*) absorb the lateral blow, (*b*) redirect the forces away from the knee joint, and (*c*) prevent opening of the medial knee joint.

and is done under completely anaerobic conditions.[16,20]

Lephart et al[17] reported TAE to correlate well with anaerobic power (M-K step test; r = .73), although further investigations should substantiate these findings. Similarly, Kalamen[15] reported a high correlation (r = .97) between the time of running the 50-yard dash and the M-K step test. This suggests that the 50-yard forward sprint may be used as a valid measure of anaerobic power. Although our study used the 40-yard forward sprint, we feel this distance is comparable to the distance used by Kalamen,[15] and may also be used as a valid measure of anaerobic power.

Peak torque and TAE during knee extension is a reflection of the quadriceps maximal tension generating capacity[4] and any deficits in the quadriceps capacity to generate tension should affect the potential for forward sprint speed. The relationship between muscular strength and sprint speed has not been extensively investigated and strong relationships are not widely reported.[5,8,18] The hip flexors are most active during sprinting; apparently because they are closely linked to the knee extensors in propelling the body forward.[19] This suggests that the biarticular knee extensors/hip flexors may provide the necessary impetus for sprint speed due to their high activity during sprint running. According to our study, there appears to be little relationship between quadriceps strength/power and sprint speed. This may be due in part to the small subject size. Overall, when comparing muscular strength and sprint speed, few have revealed consistencies between muscular and functional inhibition indicating the necessity for further investigation.

Since wearing the prophylactic knee brace appears to inhibit isokinetic muscular strength parameters and sprint speed, we speculate that the brace may inhibit some other functional performance parameters. Studies identifying the effects of prophylactic knee bracing on agility are limited[7,25] and results are not consistent within the literature. Again, further studies are necessary.

In addition to the results from the muscular function inhibition studies, some researchers have suggested that other factors may affect sprint speed. Van Horn et al[32] reported that when prophylactic knee braces were worn, significant differences in gait patterns were observed. These alterations were speculated to be some form of compensatory motions to counter the effects of the brace. This may have implications for future improvements in brace design and placement.[26,33]

Prophylactic knee braces have been under investigation for some time. Most researchers have found the prophylactic knee brace to be ineffective in preventing injury to the knee joint, yet many clinicians and athletes continue to recommend and use the brace. The results of this study reveal that the prophylactic knee brace does indeed inhibit selected isokinetic muscular characteristics and forward sprint speed in subjects who are unaccustomed to wearing prophylactic knee braces, and both of these factors may ultimately inhibit athletic performance. Furthermore, the difference between the two mean sprint times appears to be small for this study (Table 1), yet deficits as small as one tenth of a second may be practically significant for athletes who demand maximal speed. Therefore, the use of prophylactic knee braces for athletes who require maximal muscular function and sprint speed should be scrutinized with regards to the limited reported prophylactic benefits of such braces.

This study used subjects unfamiliar with prophylactic knee brace use, thus providing a novel motor task for the subjects. Conversely, athletes who are accustomed to wearing prophylactic knee braces have conditioned an ingrained (habituated) motor task relative to their performance. The novelty of the task for the subjects in this study may affect the external validity of the study. Therefore, any significant effects demonstrated by the subjects in this study may be due to the unfamiliarity of the tasks and will make generalizability to the athletic population difficult. For future research, we recommend using athletes who are accustomed (habituated) to wearing the prophylactic knee brace in order to increase the generalizability of our results to a more habituated athletic population. We also recommend investigating further the relationship between muscular strength/power and sprint speed, as well as investigating the braces' effects on other performance variables, such as proprioception, metabolism, kinetics, and kinematic function.

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